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TENTATIVE ESTIMATE OF THE THRESHOLD RESPONSE OF A TELEVISION SYSTEM FROM STELLAR OBSERVATIONS

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SUMMARY

By tentatively estimating the threshold response of a television system from stellar observations, the authors show that the use of a highly sensitive television system allows the registration of radio emission from stars of 20 to 21^m by means of an average-size telescope and an exposure time from a few seconds to one minute. This is close to the theoretical limit of observations of light fluxes of limit small values. Therefore, the use of television method opens broad possibilities for the observation of fast processes in stars. Author

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Light fluxes of limit small values must be measured against the nig night sky emission background for the observation of weakest stars. To achieve such measurements it is necessary to have a light receiver with a high quantum yield. These requirements are to a significant extent satisfied by a television system worked out especially for the measurement of weak light fluxes [1] and utilized with an additional brightness intensifier [2]. The experiment for determining the threshold response of that system by stellar observations was conducted at the Crimean Astrophysical Observatory of the USSR Acadey of Sciences, using an MTM-500 telescope (D = 500 mm, F = 6.5 m, optical transmission factor near 0.3).

* OPYT OTSENKI POROGOVOY CHUVSTVITEL'NOSTI TELEVIZIONNOY SISTEMY PO NABLYUDENIYAM ZVEZD.

For this telescope, the number of quanta of light, originating from a star of magnitude m, of spectral class G2 during the time t, will, according to [3], be determined by the expressions

$$\bar{N}^* = 2.2 \cdot 10^{9 - 0.4\,m}\, t. \qquad (1)$$

The flux of quanta from sky background, originating from an area equal in size to star image (3" or 0.1 mm in the focal plane of the telescope) at sky background brightness $m_\Phi = 22^m.0$ from a square second, is

$$\bar{N}_\Phi = 36\,t. \qquad (2)$$

Transforming the equation (1), we shall obtain the dependence

$$m = 2.5(\log t - \log \bar{N}^* + 9.3). \qquad (3)$$

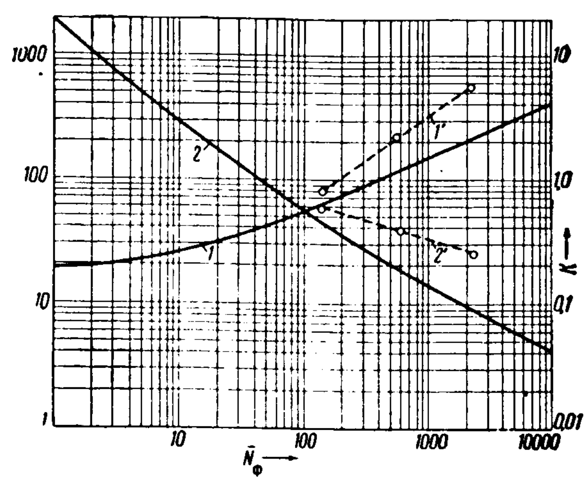

Fig. 1. - Dependence of maximum detectable number of quanta of object N^*_{min} (curves 1 and 1') and of the contrast K (curves 2 and 2') on the number of quanta of background emission N_Φ. The solid curves 1 and 2 are for an ideal receiver with $\varepsilon = 0.1$; the dashed curves 1' and 2' indicate the experimental results.

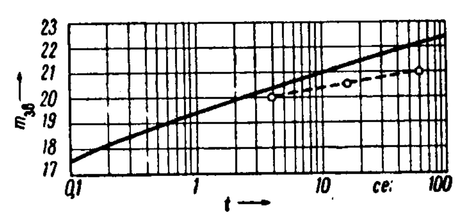

Fig. 2. -Dependence of the penetration factor of the MTM-500 telescope on the exposure time. The solid line corresponds to an ideal receiver with $\varepsilon = 0,1$; the dashed line described the experimental results.

As is well known, during observations of limit weak stars, the number of emission quanta $\bar{N}^*$ of the star and $\bar{N}_\Phi$ of the sky background from an area equal to star image dimension, are close in magnitude. It was shown by E. S. Ratner [4], that in that case the smallest number of signal quanta $\overline{N}_{min}$, registered with a probability of detection $p = 0.84$, is sufficiently well estimated by the expression

$$\overline{N}_{min} = 1 + \sqrt{0{,}75 + 2\overline{N}_{\Phi}}. \qquad (4)$$

Assuming the quantum yield of the receiver equal to ε and $\overline{N}_{min} = \overline{N}^{*}_{min}$, we have:

$$\overline{N}^{*}_{min} = [1 + \sqrt{0{,}75 + 2\varepsilon\overline{N}_{\Phi}}] / \varepsilon. \qquad (5)$$

We plotted in Fig. 1 the curves, characterizing the threshold response (curve 1) and the minimum contrast then registered $K = \overline{N}^{*}_{min} / \overline{N}_{\Phi}$ (curve 2) for an ideal light receiver with a quantum yield $\varepsilon = 0.1$ (the receiver has an amplification sufficient for the registering of every effectively absorbed quantum, while their proper noises are neglectingly small by comparison with the fluctuations of measured radiation).

Substituting the values of $\overline{N}^{*}_{min}$, determined by the expression (5) taking into account (2), into the dependence (3), we shall obtain the values of the theoretical penetration factor of the telescope for various values of t (solid curve in Fig. 2).

In order to determine the true threshold of response of the receiving device and of the penetration factor of the telescope with a television system, nearly 20 television photographs of M 3 clusters in a regime of continual readout and accumulation of information (storage time 0.3 sec) were obtained on 18 February 1964. The results of observations are brought out in Table 1 and plotted graphically in the form of dashed lines in Figs 1 and 2.

It may be seen from the graphs, that the threshold response of the television system is near the calculated one. Thus, at $t = 4$ sec it is worse than the theoretical only by 0.5^m; at the same time, the registered stars have a 55% contrast relative to the sky background.

TABLE 1 *

Exposure t, sec.	Limit stellar magn.		Number of quant. N^*_{min}	Contr. K %
	contin. readout	accum. regime on targ.		
4	20.0^m	20.0^m	80	55
16	20.2^m	20.7^m	220	40
60	20.9^m	21.1^m	530	25

* For a television photo we understand by exposure the time, during which the registered light flux is incident on the receiver photocathode.

The results of the conducted experiments show that the application of a high-sensitivity television system allows to register the emission from stars of $20^m - 21^m$ magnitude with the aid of an average-size telescope and with exposure time from a few seconds to one minute. This brings us close to the theoretcial limit of detection of limit small fluxes of light.

Thus, the application of the television method opens broad per pectives for the observation of fast processes in stars, which is of importance during studies of nonstationary stars.

**** THE END ****

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